Set 27: Chemical Reactions Part II

Skill 27.01: Be able to classify a reaction as one of the following types: decomposition, synthesis, single replacement, double replacement, combustion
Skill 27.02: Be able to balance a chemical reaction by inspection

Skill 27.01: Be able to classify a reaction as one of the following types: decomposition, synthesis, single replacement, double replacement, combustion

Skill 27.01 Concepts

There are several different ways of classifying chemical reactions. While no single scheme is entirely satisfactory, the classification scheme described here provides useful guidelines for predicting reaction types. The types of reactions introduced are synthesis, decomposition, single-replacement, double-replacement, and combustion.

Synthesis Reactions

In a synthesis reaction, two or more substances combine to form a new compound. The general form for this type of reactions is:

$$A + X \rightarrow AX$$

A and X can represent elements or compounds. AX is a compound.

Examples of synthesis reactions are shown below:

$$Mg(s) + O_2(g) \rightarrow MgO(s)$$

$$NaO(s) + H_2O(l) \rightarrow NaOH(aq)$$

Decomposition Reactions

In a decomposition reaction, a single compound separates to produce two simpler substances.

$$AX \rightarrow A + X$$

AX is a compound. A and X can represent elements or compounds.

Examples of decomposition reactions are shown below:

$$HgO(s) \rightarrow Hg(l) + O_2(g)$$

$$KClO_3(s) \rightarrow KCl(s) + O_2(g)$$

Single-Replacement Reactions

In a single-replacement or single-displacement reaction, one element replaces a similar element in a compound

$$A + BX \rightarrow AX + B$$

A, B, X, and Y are elements and BX and AX are compounds

Examples of single-replacement reactions are shown below:

$Na(s) + H_2O(l) \rightarrow NaOH(aq) + H_2(g)$

$Cl_2(g) + KBr(aq) \rightarrow KCl(aq) + Br_2(l)$

Double-replacement Reactions

In a double-replacement reaction, the ions of two compounds exchange places to form two new compounds.

$AX + BY \rightarrow AY + BX$

A, X, B, and Y ions. AY and BX are ionic or molecular compounds.

Examples of double-replacement reactions are shown below:

$Pb(NO_3)_2(aq) + KI(aq) \rightarrow PbI_2(s) + KNO_3(aq)$

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

Combustion Reactions

In a combustion reaction, a substance combines with oxygen releasing a large amount of energy in the form of light and heat. The burning of wood or natural gas are examples of combustion. When hydrocarbons are burned, they form carbon dioxide and water. Hydrocarbons are compounds made up of carbon and hydrogen.

An example of a combustion reactions are shown below:

$C_3H_8(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

Skill 27.01 Problem 1

Classify each reaction as one of the following types: decomposition, synthesis, single replacement, double replacement, combustion
(a) $Ba(OH)_2(s) + AgNO_3(aq) \rightarrow Ba(NO_3)_2(aq) + AgOH(s)$
(b) $Na(s) + H_2O(l) \rightarrow NaOH(aq) + H_2$
(c) $Ca(OH)_2(s) \rightarrow CaO(s) + H_2O(g)$
(d) $Zn(s) + I2(s) \rightarrow ZnI(s)$

Skill 27.01 Problem 2

(a) Write each reaction (b) Classify each reaction as one of the following types: decomposition, synthesis, single replacement, double replacement, combustion

(a) A piece of sodium (Na) metal is placed in water (H_2O) and produces hydrogen (H_2) gas and sodium hydroxide (NaOH)

(b) When zinc (Zn) metal is added to an aqueous solution of copper chloride ($CuCl_2$), solid copper (Cu) precipitates and aqueous zinc chloride ($ZnCl_2$) is produced.

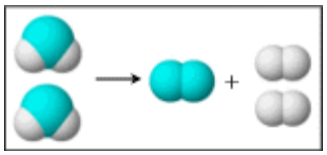
(c) When solid carbon (C) combusts in a limited supply of oxygen (O_2), carbon monoxide (CO) gas is produced.

(d) When methane gas (CH_4) is burned, carbon dioxide (CO_2) gas and water (H_2O) vapor are produced.

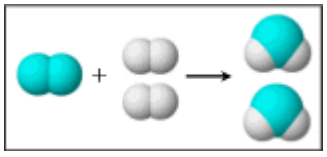
Skill 27.01 Problem 3

Classify each reaction as one of the following types: decomposition, synthesis, single replacement, double replacement, combustion

(a)



(b)



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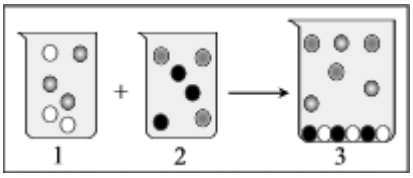

Skill 27.02: Be able to balance a chemical reaction by inspection

Skill 27.02 Concepts

Conservation of mass states the mass is neither created nor destroyed, therefore everything that appears on the left of a reaction must appear on the right. For example in the reaction below,

$$2Al(s) + 3ZnCl_2(aq) \rightarrow 3Zn(s) + 2AlCl_3(aq)$$

there are the same number of atoms of aluminum on the left as there are on the right. There are also the same number of moles of aluminum and hence the same number of grams.

The following example illustrates how to balance a chemical reaction:

Balance the atoms that appear only once on each side of the equation first

Balance polyatomic ions that appear on both sides of the equation as single units

Balance H atoms and O atoms last

If water appears in the reaction, write it as HOH. Balance H and OH separately.

Example

Balance the following reaction

$Al_4C_3(s) + H_2O(l) \rightarrow CH_4(g) + Al(OH)_3(s)$

Solution

1. Balance all elements that appear only once

   $Al_4C_3(s) + HOH(l) \rightarrow 3CH_4(g) + 4Al(OH)_3(s)$

2. Balance all polyatomic ions (Write H_2O as HOH, hydrogen + hydroxide (OH^-))

   There are 12 hydroxides (OH^-) on the right and 1 on the left so

   $Al_4C_3(s) + 12HOH(l) \rightarrow 3CH_4(g) + 4Al(OH)_3(s)$

3. Balance additional hydrogen and oxygen atoms. Done.

   $Al_4C_3(s) + 12HOH(l) \rightarrow 3CH_4(g) + 4Al(OH)_3(s)$

Skill 27.02 Problem 1

Balance the following reactions:
(a) $Na + O_2 \rightarrow Na_2O$
(b) $K + Cl_2 \rightarrow KCl$
(c) $Al + NiSO_4 \rightarrow 3Ni + Al_2(SO_4)_3$
(d) $CH_4 + O_2 \rightarrow CO_2 + H_2O$
(e) $Na + H_2O \rightarrow NaOH + H_2$